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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Special Agent in Charge.

Mayaguez, January, 1909.

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Bulletin No. 8.

PINEAPPLE GROWING IN PORTO RICO.

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BY

H. C. HENRICKSEN AND M. J. IORNS,

Horticulturists, Porto Rico Agricultural Experiment Station.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

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THE PINEAPPLE IN FRUIT.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, Chief of Division of Insular Stations, Office of Experiment Stations.

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Withdrawn
8/12/68

LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., January 20, 1909.

SIR: I have the honor to transmit herewith a manuscript by H. C. Henricksen and M. J. Iorns on the subject of pineapple growing in Porto Rico.

The data reported herein have been secured by the former horticulturist of the station, H. C. Henricksen, and the present one, M. J. Iorns, over a series of years. They have also visited other pine-growing sections of the West Indies and Florida. By comparison of methods and results many valuable lessons have been drawn that will be of benefit to this industry in Porto Rico. Besides a study of the local conditions, especially of the soils of the island with a view to their use in producing this luscious fruit, they have also made some original studies of the peculiar requirements of successful pineapple production.

I respectfully recommend that this manuscript be issued as Bulletin No. 8 of this station, and that it be published in both English and Spanish.

Respectfully,

D. W. MAY,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

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PINEAPPLE GROWING IN PORTO RICO.

STRUCTURE OF THE PINEAPPLE PLANT.

The pineapple plant consists of a short stem covered with leaves, arranged in whorls, and supported by the roots, which are directly attached.

ROOT.

The roots are fine and branched or in single strands of as much as one-eighth of an inch in diameter, according to the conditions under which they are formed. In water cultures or in mellow soil of a uniform moisture the roots develop in fine strands which branch and reach out like the roots of other similar plants. In heavy soils or in extremely dry soils the roots are more or less coarse and usually not much branched; such roots may attain considerable length, however, and often wind around the stem of the plant instead of spreading horizontally in the soil. This is especially so with old plants which have produced several crops of suckers and to some extent with large suckers remaining on the mother plant, although these roots, while they are usually unbranched, will be found to develop in the leaf axils of the mother plant. These roots are feeding roots; if a sucker is planted in the soil immediately after removing from the mother plant, the roots will continue to develop, whereas the fine-branched roots developed in the soil often die on removing the plant. Therefore, there is not much gained in transplanting old plants with well-developed root systems. (See Pl. VI, fig. 1.)

LEAF.

The leaf of the pineapple plant is in some varieties nearly smooth, while in others the margins are covered with spines. The spines were undoubtedly intended by nature to be a protection against enemies, but in cultivated fields the only enemy from which they could protect the fruit is the rat, and it always seems able to get its share of the best pines. All other factors being equal, the spineless variety is much preferable to those with spines, and considerable progress has been made by the United States Department of Agriculture in eliminating these by crossing the spineless variety with

some of the others. It is quite possible that the same result could be obtained in the West Indies by rigid selection. Some plants of the Spanish variety brought from Florida showed a number of perfectly smooth plants in the first generation, but, as far as observed, they developed spines in the following generation. To show what an inherent characteristic the spines are, a number of leaves were split longitudinally and spines developed on the cut margins.

The color of the leaf varies from red to red striped, and red and white striped to dark green, the last being the predominating color. The dark-green color is a sign of health in most of the varieties, and whenever the leaves, which are normally green, turn reddish it is a sign of some derangement.

FLOWER AND FRUIT.

The pineapple is a multiple fruit; that is, the fruit which we know as a pineapple is really an aggregate of many individual fruits, the number of which determines the size of the pineapple. At a certain period in the life of the plant the heart—that is, the last-formed leaves—will assume a bright red color, and instead of more leaves forming, the flower head will appear on a stalk which is a direct elongation of the plant stem. The flower heads are rather conspicuous, being covered with the bright-red flower bracts. The flowers, which are inconspicuous, are of a violet or purple color. In developing, the flower head loses its bright-red color, and the terminal bracts form the rosette on top of the fruit that is called the crown. Later buds may appear on the stem below the fruit which develop into slips.

PROPAGATION.

A plant bears but one fruit, and the next crop must be produced by a new set of plants. There are several different parts from which the pineapple may be propagated, all of which are quite similar. All are miniature plants, and are known under different names according to their position on the mother plant. (See Pl. II.)

RATTOONS AND SUCKERS.

At the time the fruit is forming buds appear on the stem among the roots as well as in the leaf axils. These buds develop into individual plants, and those which are formed below the soil are called "rattoons," while those in the leaf axils are called "suckers." Either of the two forms soon develops roots, and as the roots of the rattoon develop directly in the soil, it will soon be independent of the mother plant and can be left to continue the field. The sucker, if left on the mother plant, also throws out roots, but, as it is not in contact with

PARTS OF PINEAPPLE PLANT.

1. Main plant stalk; 2, rattoon; 3, sucker; 4, head of fruit; 5, slip; 6, fruit; 7, crown slip; 8, crown.

FIG. 1.—SMOOTH CAYENNE, SHOWING SEEDS.

FIG. 2.—PLANT FALLEN OVER, DUE TO LACK OF SUPPORT IN WIDE PLANTING.

the soil, the roots develop partly around the base of the new plant under the lower leaves and partly in the leaf axils of the mother plant. In that position the sucker will grow and bear fruit exactly as if its roots were taking nourishment from the soil. The nourishment may in this case be taken up by the roots from the leaf axils where they are developing or through the stem by which the sucker is attached to the mother plant. It has been proved that the sucker grows as well after severing the connection with the mother plant as before, showing that the roots are actually taking up nourishment, although not in connection with the soil. The practical importance of this is that where the plants are close enough together to prevent the suckers from being blown over they can be depended on to bear a crop of fruit. Both the rattoons and the suckers can be severed from the mother plant at any time and used for planting. (See Pl. II, Nos. 2 and 3.)

SLIPS.

The plantlets appearing on the fruit stalk below the fruit are called "slips." They are similar to the rattoons and suckers, but they seldom attain the size of those while attached to the mother plant, and they can not reach maturity and bear fruit without being planted, as they have no chance for root development. (See Pl. II, No. 5.)

CROWN AND CROWN SLIPS.

The rosette of leaves on the apex of the fruit is called the "crown." This is similar to the slip, and when cut off from the fruit and planted it will grow and produce another fruit.

Frequently, and especially in some of the varieties, a number of slips will be found beneath and around the crown; these are called "crown slips." They are usually small because they do not have time to develop: they can be used for propagation, however, if other slips can not be obtained. (See Pl. II, Nos. 7 and 8.)

SEEDLINGS.

Practically all varieties of pineapples produce seeds in the West Indies. The quantity produced varies in the different varieties and apparently depends on the locality as well as the season. In the experimental plats on the station grounds we have frequently found fruits so seedy that they were almost inedible. (See Pl. III, fig. 1.) The seeds germinate freely, but not very quickly. The plants develop slowly until they reach the size of a small slip; after that there seems to be no difference in growth.

In propagating from seeds, plant in boxes under cover, use light soil, and cover the seeds lightly. The seedlings are subject to damp-

ing off, and it may often be necessary to sterilize the soil before planting. After the plants attain the size of small slips they can be set out in nurseries and later transplanted into the field. Seedlings will bear in from two and a half to three years, while slips bear in about one year and a half, showing that it is not practicable to propagate from seed, but it is of great importance in developing new varieties. The seeds do not reproduce the variety true to name, and in propagating from seeds the result is a number of different types, some of which may be equal to the parent, some inferior, and some superior.

SELECTING PLANTS FOR PROPAGATION.

In growing pines, the first consideration is that the plants must be free from disease, strong, vigorous, and mature. (See Pl. IV, fig. 1.) A well-matured sucker or slip can be pulled off and left exposed to wind and sun and even moisture for a long time, while the immature plant will dry up in a short time, or decay if the air is laden with moisture. There is no essential difference between a rattoon, a slip, and a sucker. Suckers often develop on the mother plant before the fruit, and such suckers will therefore be several months older than the slips and, consequently, when planted will bear several months earlier than the former.

Rattoons, although they have a developed root system, are not to be preferred to slips, because their roots die unless the plant is removed with a ball of earth. Plants in any stage of growth may be transplanted, but old, rooted plants should never be accepted in lieu of suckers. Crowns are frequently used where they can be obtained from canneries and, if large and well matured, there is no objection to planting them. The small, immature crowns are subject to rot, especially in rainy weather, and often the loss is very great. When crowns are to be planted, two precautions are necessary to avoid loss. The first is to trim close to the base of the crown. The second, to "cure" the ends by exposing for several days until there is a dry, hard surface formed. This is best done by setting the crown, base up, where the exposed surface will receive the full sunlight, which will dry out the moisture.

SOIL AND ITS PREPARATION.

In Florida most of the pineapple soils consist of over 99.5 per cent insoluble silica or sand of rather coarse texture. The mechanical analysis shows very small amounts of organic matter, very fine sand, silt, and clay. Soil of this character is not often found in Porto Rico or, as a matter of fact, in the West Indies. It was therefore a question for the pioneer planters of Porto Rico what soil to choose for pines. True enough, pines were found growing wild in many sec-

FIG. 1.—GOOD SLIPS AT RIGHT, POOR ONES AT LEFT.

FIG. 2.—SLIPS AND SUCKERS, STRIPPED AND UNSTRIPPED.

tions and in limited quantity had been cultivated near Lajas for a great many years, but nothing was known beyond the fact that pineapples would thrive there in a certain restricted locality, and it was believed that they would not thrive on soils less than a half mile distant. The practice of the last few years has shown beyond question that pines can be produced on soils of widely different character, although the best quality of fruit is produced on soils somewhat resembling those of Florida.

The three requirements of the pineapple plant are that the roots must have a limited amount of water, the necessary supply of plant food, and an unlimited amount of air. It will be understood that a well-drained sandy soil in which the individual soil particles are coarse fills some of the requirements. It will need frequent stirring of the top soil until the plants become large enough to shade and protect it from evaporation. The plant food, of course, will have to be supplied.

In clay soil and in loam and even in fine sand the conditions are not so readily controlled. A heavy rain will pack the surface, excluding the air from the roots, and, unless the land is bedded, the water is likely to remain in the soil long enough to cause serious injury to the roots.

Aeration is really the underlying principle of pineapple cultivation. The pineapple plant is not adverse to water, but the water, when filling up the soil, excludes the air. We have grown plants in jars of water for months and found the root development to be vigorous and healthy and the increase in weight of the plant equal to plants grown in soil. We have also grown plants in tubes filled with gravel previously washed with hydrochloric acid and distilled water and in similar tubes which were perfectly empty, and we found that by watering every day with a very dilute plant-food solution roots were developed and the plants increased in weight, not alone in the tubes containing gravel, but also in those which were empty and that served only to support the plant and protect the roots from light. These methods are not recommended as practical, but they serve to illustrate the nature and requirements of the pineapple plant. Methods quite similar are followed on the Florida Keys, where pineapples are often planted in a few inches of leaf mold on top of the bare coral rock, and whenever the amount of soil is insufficient to support the plant a few pieces of rock are used to hold it in place. Under such conditions pineapples will grow and produce fruit until the leaf mold is all exhausted. The reason for not producing longer is not so much the lack of soil for root formation as the exhaustion of plant food. This is further illustrated in the pineapple regions in Florida, where the soil only serves as a support for the plant and all the necessary plant food must be added. These are some of the

things known, but in applying this knowledge locally it is often found that there are other conditions which we are not yet able to explain. For instance, one soil may to all appearances be physically suited and yet be a failure, while another may seem to be anything but a pineapple soil and yet produce a satisfactory growth of plants and yield of fruit. It is therefore never safe to say that a field will or will not produce pineapples before making a practical test.

The amount of preparation needed and the methods to be followed will depend entirely upon the class of soil selected.

SANDY SOIL.

Sandy soils are those in which sand predominates and which are found between Rio Piedras and the ocean, and between the railroad and the ocean from Manati to Dorado. Such land, if it is new—that is, has not been under cultivation for many years—is usually free from obnoxious grasses and the first preparation will be to clear off the trees and shrubs, if any, and plow it to kill the vegetation. In a few weeks the sod will be decayed and the land can be worked with a harrow or any other tool suitable for fining and smoothing. After that the beds may be laid off according to the system of planting desired.

CLAY SOIL.

A clay soil is one that consists almost entirely of clay, such as is typically found in the Mayaguez district. Such land, although it may not be under cultivation at the present time, has frequently been cultivated within the last generation and often contains noxious weeds, such as malojillo grass, Bermuda grass, nut grass, etc., and it is essential that all weeds and grasses be eradicated before planting pines. Of course it is practically impossible to eradicate nut grass, but wherever the soil is full of it planting pines is not to be recommended. The preparatory step, as with sandy land, is plowing. If it is in the rainy season, it will be useless to try to eradicate malojillo and Bermuda grass and it will save work as well as greatly improve the soil to plant a cover crop which is known to grow vigorously in the locality. Such a crop will often entirely kill out the weeds and, when plowed under, will add humus, which is much needed in these heavy soils. If it is in the dry season most of the weeds can be eradicated in a few weeks by harrowing, which exposes the roots to the sun, and by gathering up and carting off some of the material if it does not dry fast enough. But under all conditions the first and absolutely essential thing is the eradication of all joint grasses before planting. The next thing is fining and smoothing of the soil. A pineapple bed should be loose, porous, mellow, and free from clods.

LOAM.

A loam is a soil consisting of clay and sand, and is called clay loam or sandy loam according to the relative amounts of these earths of which the soil is made. The typical sandy loam is found in many of the Bayamon and Rio Piedras fields and the typical clay loam in other fields in the same districts, as well as in the valleys south of the railroad in the Vega Baja and Manati districts, where there is also often an appreciable amount of humus present. These soils are much easier to work than the heavier clay soils, but they frequently require considerable preparation on account of being weedy.

METHODS OF PLANTING.

The methods of planting now followed range from single rows, 6 feet apart, planted on a ridge, to 20 or more rows, 15 to 18 inches apart, planted on level ground. All of the methods have strong advocates, and it is simply a question of which method is best adapted to certain fields, considering all of the factors that can enter into the discussion. Let us first consider a sandy soil, well drained and free from joint grasses. If the sand is comparatively coarse, the ground water not within 2 feet of the surface, and the lay of the land such that the surface water can drain off quickly, the problem is very simple. Such land should without question be planted in wide, level beds.

If the sand is fine and the drainage not perfect, the soil should be bedded up. The height and width of the beds will depend entirely on local conditions. If there are no noxious weeds to combat, the beds should be as wide as it would be possible to make them and not higher than absolutely necessary to insure good drainage.

In loam and clay soils the considerations are: To keep the soil aerated, to get rid of an overabundance of water in the shortest possible time, to be able to keep the soil free from weeds, and to prevent the fruit as well as the plants and suckers from falling over.

THE SINGLE-ROW SYSTEM.

In the single-row method the plants are set from 12 to 22 inches apart in rows from 2 to 6 feet apart. The beds are usually made by plowing two furrows together and practically no hand work is needed. This system is not well adapted to sandy soils because they dry out too quickly; neither is it well adapted to heavy clay soils for the same reason, unless the beds are made wider. In a friable loam there seems to be no objection to one row in a narrow bed, as far as the soil is concerned. If the rows are far enough apart, the system has the advantage of easier cultivation, which may to some extent be done with a horse cultivator; on the other hand there are larger vacant spaces

which it is necessary to cultivate to keep clean. If the land is full of joint grasses, the one-row system is well adapted because it is possible to enter the beds and weed, while in the wider beds this is practically impossible.

The great objection to the one-row system is that as soon as the fruit attains any considerable size it does not remain in an upright position, and when, in leaning to one side, it does not receive support from neighboring plants, it bends farther until it reaches the ground. In that position it is subject to sun scald on the upper side and will be unfit for shipment. Also, after harvesting the fruit, the suckers left on the plant are liable to be blown off and, even if they remain in an upright position until fruiting, the weight of the fruit is almost sure to bend them down. Such beds, therefore, should not be continued except by leaving the rattoons and the very lowest suckers or else replanting. (See Pl. III, fig. 2.)

THE DOUBLE-ROW SYSTEM.

For double rows the beds are laid off by plowing several furrows together and using some hand work in finishing off. The plants are set from 12 to 22 inches apart each way, leaving a margin of 6 inches or more on each side of the bed. This system can be used in any kind of soil. It has practically all of the advantages of the one-row system and the disadvantage of plants and fruit falling over is greatly reduced, although it leaves considerable to be desired in that respect. In soils that are inclined to be weedy, the two-row system is preferred to any other, but in comparatively clean soil, and especially those containing no joint grasses, beds wide enough to plant from three to six rows of pines are preferable.

THE THREE TO SIX ROW SYSTEM.

In making beds for the three to six row system the same method can be used as for the one and the two row beds, but considerable hand work is needed besides. It is good practice to leave a space of 6 feet between the beds, which should be excavated so as to leave the top of the beds at least 12 inches above the bottom of the walk between the beds. If the plants are set 15 inches apart and six rows to the bed it would require beds fully 7 feet wide. This is not too wide for working easily, provided the land is not weedy, while it almost completely eliminates the falling over of plants and fruit. It has been found, however, that where the soil is not physically well suited to pineapples the rows in the middle of the bed do not produce as well as those on the outside, and one should therefore carefully consider the conditions before laying off the beds by this method. (See Pl. V.)

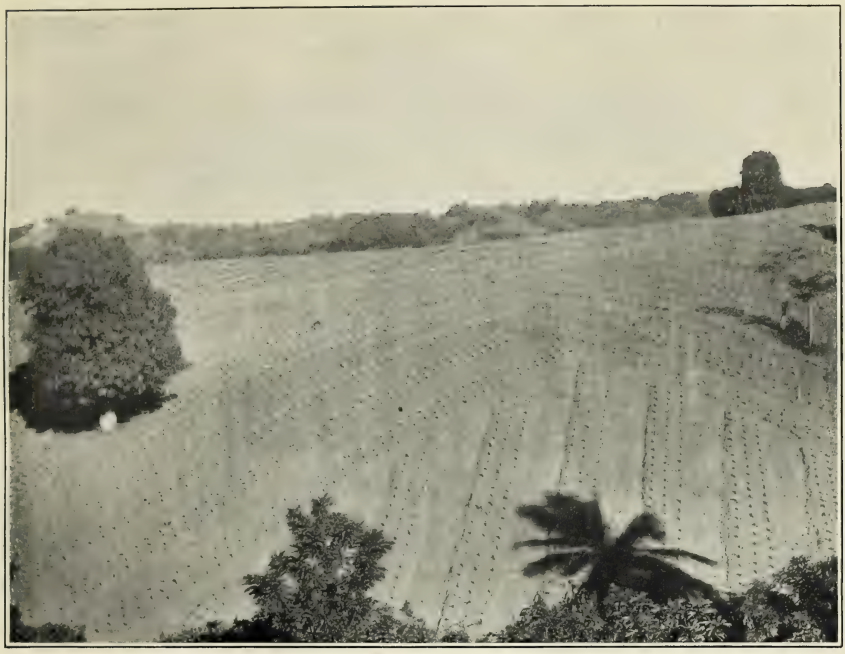

FIG. 1.—CABEZONA PINEAPPLES ON STATION GROUNDS. THREE-ROWED SYSTEM OF PLANTING.

FIG. 2.—PINEAPPLES AND ORANGES, VEGA BAJA.

THE WIDE-BED SYSTEM.

The method known as the "wide-bed system," also called "the Florida system," may be used where the conditions are similar to those in Florida, which does not often occur in Porto Rico. The land is marked off with the rows about 18 inches apart and the plants set in perfectly straight lines, which may be as long as the field, but for the sake of passing through the field there ought to be a roadway of 8 feet for every 200 feet of bed. The width of the bed is made 30 to 50 feet, according to the distance a man can throw a pineapple. In harvesting the fruit one man goes into the bed and breaks off the fruit and throws it to a man in the roadway, who catches it and places it in baskets or boxes, which are then hauled to the packing houses. In practice, beds 30 feet wide with roadways 8 feet wide, together with crossroads every 200 feet, make a very convenient field.

PREPARING THE PLANTS.

The young plants, whether suckers, slips, or crowns, are covered with leaves to the very tip of the base. In stripping these leaves off and exposing the stem a number of excrescences will be seen, which are the root buds, some of which may be already developed into roots of considerable length. Many planters maintain that it is necessary to trim the plants—that is, to cut the tip of the base and to strip the leaves off for a distance of 1 to 2 inches. Other planters maintain that this process is not at all necessary. Why is this? The reason is simply the difference in local conditions under which the plants are grown. If a slip is planted without trimming in a dry, sandy soil, the roots will form, but instead of spreading out in the normal fashion they will wind around the stem under the leaves. There are two reasons for this; one is that on account of the dry soil the leaves covering the stem remain hard and dry and the roots would have to overcome great resistance in order to penetrate them; they therefore follow the course of least resistance and develop under the leaves. The other reason is that the plant catches a great deal of dew and water from light rains, which is retained in the heart and leaf axils, from which it trickles down around the base and makes the condition there favorable for root formation, while at a distance of an inch or more from the stem the soil is drier. This growing of the roots around the stem is called in Florida "tangleroot," and there plants are trimmed in order to insure the desired root development. If the plants are set in a loamy or clay soil that contains considerable moisture, the leaves covered up with soil will decay in a short time, and as the soil is as moist a distance away from the plant as close by the roots will spread out just as well as if the plants had been trimmed. Therefore for planting in a dry soil or in a dry season, trim, but for

planting in a moist soil or in the rainy season the work is not worth the cost.

The trimming consists in cutting off the base and stripping off the lower leaves, leaving an inch or more of the stem exposed. If large suckers are planted it is quite common to cut the ends of the leaves off, but this is not desirable, because cutting or breaking the leaves lowers the vitality of the plant. (See Pl. IV, fig. 2.)

PLANTING THE FIELD.

The beds being prepared according to the desired system of culture, the rows can be marked off either with an ordinary marker or with a line, but whichever method is used the rows should be straight. The distance between the rows, as well as between the plants, will vary according to the variety and also according to the soil and the system of planting. Pineapples, no matter what variety, do not have an extensive root system, and when planted in single rows 12 to 15 inches apart they have enough room for root development. In beds with several rows, 15 to 18 inches for Spanish and other small varieties and 24 inches for Cabezona and other large varieties is space enough. Under no circumstances should pineapple plants be set over 24 to 30 inches apart in the row, because it is a waste of land, it leaves too much soil uncovered, and increases the work of weeding, while it gives no support for the plants and the fruit.

In planting it is a good plan for one man to drop the plants the desired distance apart and another man to follow with a blunt dibble with which to make holes 1½ to 3 inches deep, according to the size of the plants. The base of the plant is inserted into the hole and the soil pressed firmly down with the dibble and with the foot.

The number of plants per acre will differ, depending on the system of planting adopted. The following table gives the approximate number of plants per acre for the different systems of planting:

Approximate number of plants per acre.

System of planting.	Varieties.	Distance apart of plants in rows.	Width of paths between banks.			
			3 feet.	4 feet.	5 feet.	6 feet.
		Inches.				
Single row	Small	12	14,520	10,890	8,712	7,260
	Large	15	11,616	8,712	6,969	5,808
Double rows	Small	12 by 12	21,780	17,424	14,520	12,446
	Large	15 by 15	16,366	13,282	11,022	9,504
Three rows	Small	15 by 15	19,038	16,032	13,926	12,324
	Large	18 by 18	14,520	12,445	10,890	9,379
Four rows	Small	18 by 18	15,488	13,620	12,232	11,120
	Large	24 by 24	9,680	8,712	7,920	7,260
Five rows	Small	18 by 18	16,133	14,520	13,200	12,100
	Large	24 by 24	9,900	9,075	8,377	7,778
Six rows	Small	18 by 18	16,594	15,151	13,939	12,906
	Large	24 by 24	10,050	9,334	8,712	8,166
Thirty rows	Small	18 by 18	18,639	18,264	17,889	17,514
	Large	24 by 24	10,710	10,539	10,371	10,209

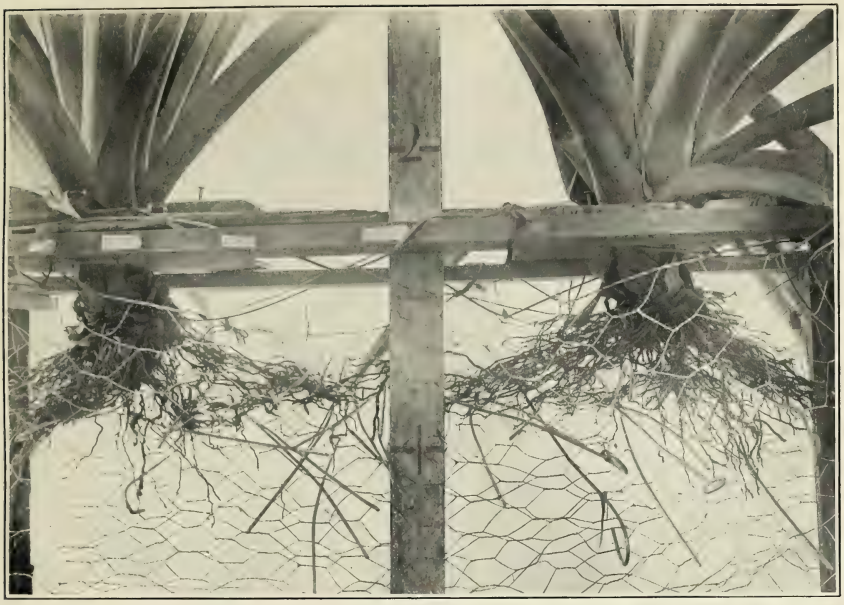

FIG. 1.—NORMAL ROOT SYSTEMS OF PINEAPPLES.

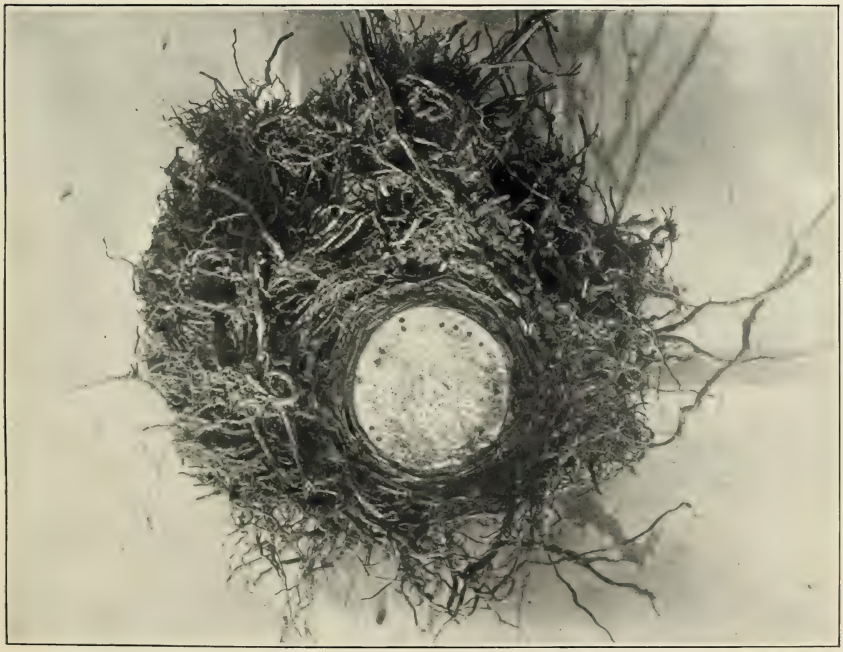

FIG. 2.—TANGLEROOT.

HOW THE PINEAPPLE PLANT GROWS.

If the soil in which the pineapple plant has been set is moist, root development will take place at once and the roots will be able to take up the food elements as soon as needed. These elements in solution are carried through the roots up to the stem and to the leaves. In the leaf cells, by action of the sun and the green coloring matter which we call "chlorophyl," these food elements from the soil and carbon dioxid from the air are combined with water into food for the plant in ways not yet fully understood. This food consists of many complex chemical compounds, the best known of which are the sugars and starches. From the leaves the food is carried in solution to all parts of the plant wherever needed. Both sunshine and chlorophyl are necessary to the formation of the principal food, so that a leaf losing its color loses its power to form food. It is thus seen how important a large, healthy leaf is to the formation of a good fruit.

Food not needed immediately is stored up in the plant tissues, usually in the form of starch, and it is this reserve supply that carries the plant over periods of hardship and vitally enters into the formation of extra-grade fruits. It is probably due to this that, as a rule, the pineapple plants that have a longer period for development will give larger fruit. They have, as it were, more accumulated reserve energy to use in the severe strain of fruit producing.

The root system of the pineapple is shallow and usually does not extend much over 6 inches in each direction. Among the larger varieties it is not uncommon to find a few roots extending 10 to 12 inches from the stem, but the main portions are matted closely together within a distance of from 4 to 6 inches. (See Pl. VI, fig. 1.)

The development of the root system is of great importance in considering planting, cultivating, and fertilizing. It will be readily understood that the plants can be set as close as 12 inches apart without the roots interfering. It will also be seen that cultivation must necessarily be shallow, especially close to the plants, and in fertilizing it would be a waste to spread the fertilizer in the middles, where the rows are 3 feet or more apart.

Where small slips are set in sandy soil it is not unusual to find them filled with sand, especially after a heavy rain or wind. This is detrimental to the plant, and the sand should be washed out by pouring water directly into the heart from a sprinkling can with the rose removed. It may also be prevented by dropping a pinch of cottonseed meal, dried blood, or tobacco dust, or a mixture of any of these materials, into the heart immediately after planting. This, by filling the cavity, will prevent the sand from entering, yet, unlike the sand, it will not choke the plant.

CULTIVATION.

On account of the shallow root growth and the close planting, cultivation is confined almost entirely to hand work. With the single-row or narrow-bed system some horse work can be done the first season, but after that the leaves interlace and with horse cultivation more or less damage is caused by breaking and tearing the leaves. The extent of the damage compared with the difference in the cost of cultivating will naturally determine the best method to be employed, but some hand work will always be necessary. On the sandy soils in Florida the scuffle hoe is generally used, but on the heavier soils in the West Indies it is necessary to use the ordinary hand hoe, not alone on account of the heavier soil, but also because of the much more abundant growth of weeds. Wherever the land is weedy, cultivation should be strictly attended to, because a crop of weeds is detrimental to the growth of the pineapple plant; and if left to grow, large weeds are much more difficult to eradicate than if attended to in time.

FERTILIZERS.

A great many soils in the West Indies can produce pineapples without being fertilized, but the writers have not noted a single instance where an application of the proper kind of fertilizer did not exert a beneficial influence, either on the fruit or on the plant or on both. Although the pineapple belongs to the natural order of Bromeliaceæ, many of which are air plants, the pineapple requires more than air for its development. It is true that it does grow in poor soils, but the Florida planter learned many years ago that no fertilizer meant few pineapples, most of which were too small to ship. In the West Indies the rich soils always produce the largest plants but never the best grade of fruit, and here fertilizers become necessary in order to improve the quality.

ACTION OF FERTILIZERS.

In dealing with fertilizers the only elements in which we are interested are nitrogen, potash, and phosphorus. The action of nitrogen is especially in the formation of foliage; therefore a soil containing large amounts of it compared with potash and phosphorus produces large plants. For fruit, potash is the ingredient especially needed, and its rôle seems to be to give firmness and shipping quality as well as flavor. The stimulating action of a fertilizer can often be detected in the plants a few days after it has been applied, and with a little experience the grower can tell when his plants need fertilizing. The lack of fertilizer is usually manifested in a turning of the leaves from dark to a lighter green, and

often light red color. This change of color can also be caused by a lack or an excess of moisture, or by insects at the roots, but often, even in those cases, an application of fertilizer will restore the normal color.

On account of the method of application, it is essential that the fertilizer ingredients should not be caustic or acid, so as to injure the foliage. As all inorganic salts cause more or less injury when applied in the heart of the plant, it becomes necessary to employ some of the ingredients in an organic form. For nitrogen, neither nitrate of soda nor sulphate of ammonia can safely be used in the crown. As a source of nitrogen, cotton-seed meal is very good and dried blood is very desirable also, as well as high-grade tankage.

For phosphorus it is not safe to use the acid phosphate in large quantities, especially the double acid phosphate, which seems to be more acid than the regular 14 to 15 per cent product. Steamed bone is very good; it causes no injury and the pineapple will be able to take from it as much phosphorus as is needed, provided it is thoroughly steamed and flocculent. A ground bone in which the particles are granular is not so valuable, because the phosphorus in it is too slowly available. Basic slag can also be used, but although it does not cause as much damage to the foliage as acid phosphate it should be used with caution.

For potash the sulphate should be used, either the high grade, containing 50 per cent potash, or the low grade, containing about 27 per cent potash. Ordinarily these salts cause no injury, but experiments have shown that it is not safe to apply potash alone to small plants, although a pinch may be safely scattered in the leaf bases of large plants.

METHODS OF APPLYING.

As previously explained, the root system is very shallow and extends only a few inches away from the stem, therefore the soil in that small space must be rich in plant food in order to produce a large plant and a marketable fruit. In experiments covering over three years it was found that one of the best ways for the plant to take up nourishment is to absorb it from a solution trickling down the stem from the leaf bases. This is fortunate, because in field practice it is difficult to apply fertilizer in any other way than spreading it over the plants. Even where the rows are 3 feet apart the leaves interlace and a great deal of fertilizer drops on the inclining leaves and rolls down and lodges in the leaf axils. The writers recommend scattering the fertilizer so that most of it will lodge directly in the leaf axils. On single rows or on small plants it is best to fertilize each row by itself. On wide beds and where the plants entirely cover the ground, the fertilizer can be spread broadcast and only a limited amount will fall on the soil.

WHAT TO USE AND WHEN TO APPLY FERTILIZERS.

The experiments are not yet conclusive enough to show the amount of the various ingredients that can profitably be used on the different soils, nor is it known how often the fertilizers ought to be applied, but for the sandy soils the ratio of 10 pounds nitrogen, 20 pounds potash, and 8 pounds phosphorus per 1,000 plants seems to give good results. On the loam soils the nitrogen may often be omitted and the amounts of phosphorus and potash cut to one-half. As to the time of applying, it was found that the plants made the most uniform growth and kept in the best condition when the fertilizers were applied in small quantities and as often as every three to six weeks. This is what might be expected from applying the fertilizers in the leaf axils, because during the rainy season the salts will wash down in a short time, while in the dry season the leaf base solution will be much too concentrated for the plants to feed upon if the amount applied is very large. Whether the frequent applications will pay for the extra cost of labor is not yet known, but it seems probable that the first crop should receive not less than four applications and the succeeding crops not less than two.

The fertilizer formulas given here are intended for the ordinary sandy soils and will be found useful whether the fertilizers are made in a factory or at home. If made at home, the fertilizer should not be mixed any length of time before needed, because there is always a possibility of ammonia escaping. The basic slag should under no consideration be mixed and left standing together with the blood, tankage, or cotton-seed meal, because it will induce a liberation of ammonia, which will be lost.

FIRST APPLICATION.

As the pineapple starts to take up nourishment shortly after planting, the first application can safely be made immediately after the plants are set. This should consist of some nitrogenous organic material only, such as cotton-seed meal, tankage, or dried blood, which may be advantageously mixed with tobacco dust if that can be obtained. A quantity sufficient to fill up the whole cavity should be dropped into the heart of each plant.

SECOND APPLICATION.

The second application should be made from two to three months later in the following quantities, which will supply 4 pounds nitrogen, 4 pounds potash, and 2 pounds phosphorus per 1,000 plants:

30 pounds dried blood.
8 pounds high-grade sulphate of potash.

Or

16 pounds low-grade sulphate of potash.
10 pounds steamed bone meal.
7 pounds acid phosphate.

Or

40 pounds tankage, containing about 10 per cent nitrogen.
8 pounds high-grade sulphate of potash.
5 pounds basic slag.

Or

30 pounds cotton-seed meal.
12 pounds nitrate of soda.
8 pounds high-grade sulphate of potash.
15 pounds steamed bone meal.

THIRD APPLICATION.

The third application should be made six months later, which will be in April or May provided the plants were set in July or August. The following amounts will furnish 3 pounds nitrogen, 6 pounds potash, and 3 pounds phosphorus and should be applied to 1,000 plants:

22 pounds dried blood.
12 pounds high-grade sulphate of potash.
30 pounds steamed bone meal.

Or

30 pounds tankage.
12 pounds high-grade sulphate of potash.
10 pounds basic slag.

Or

42 pounds cotton-seed meal.
24 pounds low-grade sulphate of potash.
14 pounds acid phosphate.

FOURTH APPLICATION.

The fourth application, which in this instance is the last, should be made about two months previous to blooming, which would ordinarily be in October or November for plants set from fourteen to fifteen months previous. The following amounts will furnish 2 pounds nitrogen, 10 pounds potash, and 3 pounds phosphorus per 1,000 plants:

14 pounds dried blood.
20 pounds high-grade sulphate of potash.
10 pounds steamed bone meal.
10 pounds basic slag.

Or

20 pounds tankage.
40 pounds low-grade sulphate of potash.
10 pounds steamed bone meal.
9 pounds acid phosphate.

Or

30 pounds cotton-seed meal.
20 pounds high-grade sulphate of potash.
12 pounds basic slag.

SUBSEQUENT APPLICATIONS.

If the field is continued—that is, if the suckers and rattoons are left to produce another crop—the plants should be fertilized immediately

after gathering the fruit, and a second application should be given about two months before these plants show bloom. This last fertilization is especially valuable, as the size of the flower head determines the size of the fruit. Fertilizers should not be applied at the time the flower head is forming, because it is very tender, and chemicals dropped into the heart at that time will often cause the fruit to be stunted, crownless, or otherwise deformed. There is no objection to fertilizing after the fruits have set, and a small application of potash at that time may often improve the shipping quality of the fruit, which might otherwise be too soft.

The application following the harvest may be made so as to supply 6 pounds nitrogen, 8 pounds potash, and 4 pounds phosphorus per 1,000 plants in the following combinations:

43 pounds dried blood.
16 pounds high-grade sulphate of potash.
29 pounds acid phosphate.

Or

60 pounds tankage.
32 pounds low-grade sulphate of potash.
10 pounds basic slag.

Or

43 pounds cotton-seed meal.
13 pounds nitrate of soda.
16 pounds high-grade sulphate of potash.
30 pounds steamed bone meal.

The application before fruiting may be made so as to supply 4 pounds nitrogen, 12 pounds potash, and 4 pounds phosphorus per 1,000 plants in the following combinations:

40 pounds tankage.
48 pounds low-grade sulphate of potash.
13 pounds basic slag.

Or

43 pounds cotton-seed meal.
48 pounds low-grade sulphate of potash.
10 pounds steamed bone meal.
10 pounds basic slag.

FERTILIZER FOR SOILS RICH IN NITROGEN.

There are many localities in Porto Rico in which the pineapple plant grows luxuriously, but produces small fruit. Usually, however, when the natural conditions are favorable a large healthy plant will produce a large fruit; but if the soil is rich in nitrogen and deficient in potash and phosphorus, the quality of the fruit will be inferior. Frequent reports have been received of large shipments of fruit arriving in New York with 75 to 90 per cent decay, while other shipments on the same boat arrived with only from 5 to 10 per cent decay. This may be, and often is, caused by excessive rains in the localities

from which the poor pines came; but in comparing the soils and the fertilizer used doubtless the unbalanced supply of plant food was largely the cause. Experiments to prove this are not yet completed, but with the present knowledge the writers would recommend an application of 20 pounds of high-grade sulphate of potash per 1,000 plants just before the first sign of bloom.

SUMMARY.

The following table gives a summary of the different fertilizers recommended for use and times of their application. In the second and following applications three different mixtures are recommended:

Summary of fertilizer applications.

[Amount per 1,000 plants.]

Number of application.	When made.	Dried blood.	High-grade sulphate of potash.	Low-grade sulphate of potash.	Steamed bone meal.	Acid phosphate.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
First	At planting	(a)				
Second	2 to 3 months later	30	8, or	16	10	7
Or	do		8			
Or	do		8		15	
Third	6 months later	22	12		30	
Or	do		12			
Or	do			24		14
Fourth	2 months before bloom	14	20		10	
Or	do			40	10	9
Or	do		20			
Fifth	Following harvest	43	16			29
Or	do			32		
Or	do		16		30	
Sixth	Before fruiting, second, third, etc., crops.	29	24		20	13
Or	do			48		
Or	do			48	10	

Number of application.	When made.	Tankage.	Basic slag.	Cotton-seed meal.	Nitrate of soda.
		Pounds. (b)	*Pounds.*	*Pounds.* (b)	*Pounds.*
First	At planting				
Second	2 to 3 months later				
Or	do	(c) 40	5		
Or	do			30	12
Third	6 months later				
Or	do	30	10		
Or	do			42	
Fourth	2 months before bloom		10		
Or	do	20			
Or	do		12	30	
Fifth	Following harvest				
Or	do	60	10		
Or	do			43	13
Sixth	Before fruiting, second, third, etc., crops.				
Or	do	40	13		
Or	do		10	43	

a Enough to fill crown. b May be used in place of dried blood. c 10 per cent nitrogen.

VARIETIES.

To classify the varieties of pineapples in the West Indies in such a manner that the classification may be of practical value to the planters seems an almost hopeless task. In Porto Rico alone the same variety shows distinct characteristics in the different parts of the island, and the varieties imported from other West Indian islands under given names are wholly different from those already growing in Porto Rico under those names. Furthermore, new types are constantly originating from seeds. Types are formed by degenerated varieties escaped from cultivation and some are found in the Manati section in Porto Rico of which it is difficult to judge if they have ever been under cultivation. The varieties known and commonly planted in Porto Rico until a few years ago were Cabezona, Pan de Azucar, and Negrita. In the last few years the variety known as Red Spanish has been planted extensively, and several varieties have been imported from the various West Indian islands by the experiment station and in a few cases by individual planters.

CABEZONA.

In Florida the Cabezona is classified as the Porto Rico, which would indicate that it came to Florida from Porto Rico. It is not known whether it originated in Porto Rico, but, according to hearsay, it has been grown at Palmarejo, a village about 2 miles west of Lajas, since the earlier part of the nineteenth century. In 1903 the entire planting at that place amounted to about 135 acres, and the amount of fruit shipped from there was approximately 140,000 pines. At that time there were about 100 acres planted to the Cabezona in the Bayamon section also, but it was noticed that the plants were smaller, the leaves narrower, the color lighter, and the fruit distinct in flavor from the Palmarejo fruit.

The Cabezona is one of the largest varieties grown. The plant is large, with broad, dark green, spiny leaves. The fruits vary in shape from oblong, tapering, often irregularly bulging, to almost cylindrical with regular sides. The Palmarejo fruit averages 8 to 10 pounds. Twelve to 15 pounds is very common and as high as 25 pounds has been reported, although the writers have seen none that weighed over 18 pounds. The color of the fruit is a dark green, turning to bright yellow when ripe. The crown is large and regular and crown slips are not often found. The fruit stalk is large and extends up into the fruit, so that when broken off it leaves a cavity.

RED SPANISH.

Just as in the Cabezona, there is considerable variation in the Red Spanish in the different parts of the island. It is not definitely known

who brought in the first plants or where they were brought from, but in 1905 and 1906 large shipments were made from Florida and some from Cuba. Some have been brought in from other of the West Indies, so that at present there are a number of strains, but these are not distinct and can not be readily distinguished. Changes due to soil, cultivation, and climate are often greater than the strain difference.

In general the fruit of Red Spanish is small to medium, somewhat cone-shaped, and of medium quality. Ofttimes the fruit is so short compared to its diameter that it has a flattened appearance. The eyes are relatively quite large, and when ripe have a bright, clear red color. The plant is vigorous, but not as large as the Cabezona. Its leaves are reddish green at tips, changing to a bluish green near base. They should be quite wide relative to length, and with heavy thick base. The fruit breaks off clean and close to base, and with little danger of being injured. Just before blooming the center turns bright red, thus affording an indication as to time of fertilizing for fruit.

The plant quickly shows poor growing conditions by turning reddish or losing color and becoming yellow. It is very susceptible to the soil conditions and to methods of culture and fertilization. It slips well and thus propagates rapidly. Data from many fields show an average of over five slips per plant, and the writers have often counted twenty and more slips, suckers, and rattoons on a single plant. This rapid multiplication, together with excellent shipping qualities, make the Red Spanish the great commercial variety of the present, though many others surpass it in quality.

Aside from these two leading varieties, there are a large number of native and introduced forms. At the station some twenty and more introduced and selected varieties are being tested and a number of seedlings are being grown, but thus far none give promise of soon replacing the Red Spanish and Cabezona. Some of the new varieties produced on the experimental grounds at Miami, Fla., far surpass all other varieties, and one selection made by this station, a variegated Cabezona, gives considerable promise for a fancy decorative pine, but it will be many years before these can be produced in quantities sufficient to supply the markets.

Since conditions govern size, quality, flavor, and even form, it is not profitable to enter into the description of any of these many varieties. When some variety becomes prominent enough to become a commercial possibility, then will be time to give a full description.

FRUITING.

The time necessary to produce a fruit depends upon many factors, some of which can be controlled, while others can not. The con-

trollable ones are size and condition of slip, cultivation, and fertilization. The chief uncontrollable ones are the climatic conditions prevailing after planting. As a rule, vigorous slips, 12 or more inches long, large suckers, and large rattoons will produce fruit in one year or less, depending upon conditions named above. Results, as far as obtained from many experiments under way, indicate that it is better to set younger plants, and wait a few months longer for the fruit, because the rapidly maturing plants do not seem to have the vitality and reserve force necessary for producing the largest and best fruit. As to which will fruit first, a slip or a sucker, all depends upon conditions of vigor, age of plant, and culture. Slips and suckers of the same age and vigor, under the same growing conditions, will, as a rule, show little or no difference, but according to data collected the sucker usually produces fruit first, because it is often much more advanced. Whether by culture and fertilizers as good fruit can be produced in ten to twelve months as in fourteen to eighteen months is a question for close investigation. Such a comparison should include cost, the difference in time and culture, and the gain in quality and size of the fruit.

In those countries where there are climatic seasons, there is a distinct period for planting and a distinct period for fruiting, and such was generally true in Porto Rico until within the past two or three years. The demand for fruit caused plantings to be made at all seasons with plants of all grades, and as a result fruit is maturing in all months. It is even yet a question whether definite seasons will not come again, but it is probable that a planter by varying the controllable factors can mature most of his fruit at any desired time of the year. From the marketing standpoint this is very important, for he can thus mature his fruit at the season when the prices are best. This will necessitate each planter's keeping careful and complete records of his work and local conditions.

MATURITY OF FRUIT.

The proper degree of ripeness for gathering is very difficult to describe, especially as the fruit begins to mature at base and at core first, so that one portion of the fruit is riper than another. Much depends also upon the length of time necessary to put the fruit into the consumer's hands.

There are several ways of judging the degree of ripeness. These are the development of the crown, the slips, the eyes, the bracts or little leaflets at the eyes, and the general color. As the pine ripens, the crown opens out, the eyes flatten, and the margins round up; the spaces between the eyes open and grow lighter in color; and the little leaflets wilt, then shrivel. As most fruit is picked quite green, only much experience and testing will give one any degree of skill in

determining just the condition best for picking. As a rule the more nearly ripe the pine can be allowed to become before gathering the better the quality; but usually the pine will ripen and color fairly well after being gathered if the eye margins are well rounded, the spaces between show a light greenish yellow, and the leaflets are wilted or withered. If gathered earlier, the fruit may apparently ripen, but the quality will be poor and usually the color as well.

If the fertilizer has been well balanced and other conditions what they should be, the fruit can be left until more mature, and hence of higher quality. A soft fruit indicates improper soil or fertilizer conditions.

YIELD.

The yield of pineapples is such a varying quantity and dependent upon so many factors that it is almost impossible to make any definite statements. From data gathered from prominent growers in different parts of the island, it is probable that 93 per cent of the Red Spanish plants should yield fruits, 60 to 70 per cent of which would grade as 24's or larger. With the Cabezona variety 50 to 60 per cent of the plants should bear fruits, 95 per cent of which would be 24's or larger. Some growers obtain from 98 to 100 per cent fruiting plants, 70 to 80 per cent of the fruits grading 24's or more. It is here that the test of the whole system lies. It is the yield in its broad sense of both quality and quantity that determines the grower's success.

FIELD AFTER FRUITING.

How to treat a field after the crop is gathered becomes a complex question where the fruit is ripening over such a long period. As shown under the discussion of fertilizers, as soon as the fruit is gathered the plant should be fertilized. Where fruit matures very irregularly this can be done by having a man go over the field after every heavy picking and fertilize the plants from which the fruit was just gathered. The small expense will be more than gained in growth of slips and suckers.

A second need after fruiting is a thorough cleaning and cultivation. This is difficult to accomplish, as it is not wise, if it can be avoided, to cultivate strongly those plants having fruit nearly mature. Such cultivation may result in renewed growth and yield soft fruit. On the whole, it is best to wait until the most if not all the fruit has matured for the thorough cleaning of the field. At the time of cleaning, all diseased and poor plants should be removed and their places, as well as all vacancies, filled with strong, vigorous ones.

At this time some advise cutting off the leaves of the old plants. While it is a good plan to clean the plant from dead or badly injured leaves, it is not advisable to cut others except in special cases. If the

field is in such a condition that good work in cleaning can not be done without it, then it may be best to cut off the old leaves. It must be remembered, though, that the leaves are the part that change the elements of the soil and air into food for the plant and any injury to them decreases the amount of food that can be formed in a given time.

As the root system is very shallow, if there has been much washing or working away of the soil, the earth should be thrown into the bed around the plant to the depth of 3 to 4 inches. This not only covers the roots, but also helps support the old plant. Care should be used to see that the middle of the bed is kept higher than the sides to assist drainage.

As fast as they mature the slips and suckers should be removed. If all are not desired for planting, then it is well to remove the smaller, weaker ones as soon as possible, thus throwing all the strength of the plants into the ones needed. The number of rattoons and suckers left to bear the next crop depends on the bedding and richness of the soil. Usually two are left to each plant. If the ground is very rich and one expects to fertilize well, three and even in extreme cases four of the best rattoons and suckers may be left. In the single-row system only the rattoons or possibly the very lowest suckers can be left, as any others would probably fall over and either break off or allow the fruit to be sun scalded. In a several-row system the retention of only the lower suckers and rattoons is not so necessary, and the closer the plants the more this is true, but in all cases suckers from near the top should be avoided if possible. Usually, if the upper suckers are pulled off, others will be formed lower on the plant, and even the development of rattoons can often be caused by removing the suckers first formed.

The length of time a field may be kept continuously in pineapples depends most upon its fertility, but the nature of the soil, the weeds and grass, the system of bedding, and the tendency of the mother plants to propagate by rattoons or low suckers also are governing factors. Where the ground is strong, heavy, and weedy, it is probable that three to four years is as long as the field can be economically continued. In such cases a rotation of three crops of fruit, then a deep plowing and two or three cultivations, then about two good crops of cowpeas, at least one of which is turned under, then another deep plowing and thorough cultivation, followed by replanting with pines, will prove very satisfactory. The cultivation and two crops of cowpeas should not take more than eight or nine months and would more than pay for the loss of time. When the other factors can be controlled, a field may be continued from eight to fifteen years, or as long as the fertility is such as to keep the fruit

up to profitable size. In Florida this is from five to ten years; in Cuba, five to eight years; and in the Bahamas, in exceptional cases, as much as fifteen years.

MARKETING OF PINES.

To grow a first-class pineapple requires more skill and intelligence than is usually considered necessary, but to market it well requires even more. "Marketing" embraces two quite distinct operations: First, the preparation for the market; and second, the actual finding of the market, the transportation thereto, and the selling of the fruit. The preparation of the fruit for the market involves two series of operations—those of the field and those of the packing house.

GATHERING.

In the picking of the fruit, the method of bedding, the variety, and the size of the plants influence the method used. Pineapples, probably because of their appearance, are commonly considered able to stand rough handling. On the contrary, they are very susceptible to injuries, especially in the field before curing, and should be handled almost as carefully as are strawberries or ripe avocados.

Because of the spines, the pickers should wear long-sleeved, heavy canvas gloves, and where they must walk through the pines it is also well to have protection for their bodies.

Stiff bushel baskets are best for collecting the fruit. In the one-to-five row systems of bedding each picker carries his own basket. In larger beds it is more economical to have extra men to collect fruit from the pickers, regulating the number of baskets by the quantity of pines. Each fruit should be placed in the basket, not thrown or dropped. The Red Spanish can be broken off its stem by a quick sidewise and downward jerk or by placing the knee against the fruit stalk and giving the fruit a quick jerk across the knee. The Cabezonas must be cut off, since, if broken like the Red Spanish, the stem will break deep into the fruit and decay will soon follow. A good way is to cut a long stem with a machete, and then in the packing shed arrange a cutting knife like that used in stores for cutting tobacco, dried beef, etc. Keep the knife sharp so it will make a clean, smooth cut flush with the base of the pine, being careful not to bruise the fruit. All other varieties are treated like the Red Spanish or the Cabezona, depending upon how they break from the stem.

COLLECTING CRATES.

From the picker's basket the fruit is transferred to the crates for transportation to the packing shed. It is here that much fruit is injured by roughness and carelessness. The fruit should be trans-

ferred by hand and not dumped or thrown out. Care should be taken also to see that the fruit of one is not crowded against the crown of another, as the punctures caused by the spines afford ingress to spores of decay. The collecting crate should be deep enough to hold not more than two layers and allow another crate to be placed upon it without touching the fruit. The crates should also "nest" into one another so they will hold firm upon the wagon. This nesting can be easily made by nailing strips around the outside of each crate, allowing the strips to project from one-half to one inch above the ends and sides. Care should be taken to see that there are no nail points, slivers, or projections of any kind that can injure the fruit. It is natural, when transportation facilities are not first class, to lay the poor carrying of fruit upon the transportation company. Even if the transportation facilities are poor, it is safe to say that a considerable proportion of the rotting of the fruit is due to injuries received by carelessness in gathering and preparation for shipment.

In hauling to the packing house, wagons with good springs should be used, as fruit unpacked is more susceptible to being injured by jars than when packed.

PACKING HOUSE.

It is impossible to design a packing house that will meet the needs of all conditions and packers, but there are certain essentials that govern every well-arranged house. These may be summed up as follows:

(1) Arrange so that one operation will not interfere with another. The entrance for fruit should be on one side and the exit on another, and the curing, grading, sizing, packing, and final operations should be so arranged that they will come in the above order and be continuous.

(2) Avoid as far as possible all lifting or lowering of the fruit, either packed or unpacked.

One of the best arrangements is to have the main packing floor about on a level with the wagon box. Have floor space enough to let the fruit cure in the field crates. Let the bins for graded and sized fruit be along one side or across one end of the building and open at both ends, so that they are filled from one side and emptied from another. From each bin run a packing bench of proper height, and let these benches be continuous with the bench used for nailing up the boxes, so that the boxes of fruit can be slid along the bench from packer to nailer and from nailer to finisher and stenciler. This saves all lifting and possible dropping of the packed boxes, and the principle can be applied in many modifications to suit conditions. If economy of room is necessary, the boxes can be made in a basement below

and raised by means of a simple elevator, or made in a room above and slid down a properly arranged chute.

(3) The house should be made as cool and dry as possible.

(4) Keep everything clean. Do not, as is too often done, allow decayed or diseased fruit to lie around. Each diseased or decayed fruit is able to render the air of a whole packing house dangerous to all other fruit therein, especially if any such fruit should have even the slightest break in its skin.

CURING.

The time necessary for curing depends upon the conditions just before and during picking. If the fruit is picked in dry weather, cooling is the essential factor. The fruit should be put in an open, dry, shady place one night, or at the most two. If gathered when moist or during wet weather, as is sometimes unavoidable, then the fruit must be dried as well as cooled, and this will sometimes require three or four days. For this curing set the pines on their crowns base up. This necessitates the curing shed being as cool, dry, and airy as location and construction can make it. Damp and uncured fruit is often shipped, and may carry through in good condition, but it is not safe to take the risk.

GRADING.

It is questionable if it is advisable to make more than one grade for shipping. If a local cannery is available, the culls could be worked up there, as the margin of profit on shipped fruit generally hardly justifies shipping second-grade fruit except at times of especially high prices. First-grade fruit should be free from sun scald or other injury, of good form for the type, of proper degree of maturity, and of good quality. Some of these are difficult to determine, but one handling much fruit can, by close observation, grade very accurately. In a strictly first-grade pack the crown should also receive consideration, all the pines being as uniform as possible.

SIZING.

The methods of sizing are exceedingly varied, most of it being done by the eye alone. One of the serious criticisms of Porto Rico fruit is its irregularity as to sizing. One brand of 24's will not be the same as another brand, and, worse yet, the sizes of the same brand will not be uniform. It is next to impossible for the eye alone to size uniformly, as it is too easily deceived by variations in crown, form, etc. As yet there is no system perfected to the extent that there is for oranges and grapefruit, and probably never will be, unless we develop more regularly formed fruits. Aside from the eye system there are two others quite largely used with various modifications. One is by

weight and the other is by sizers. The sizers are of three general styles. One of the simplest and also the best is a " V " shape with the different sizes marked on the side. The fruit is taken up by the crown and placed in the sizer till it touches gently each side, and the side lines then mark its size. Care must be taken to see that the greatest diameter of the fruit is invariably used.

Another style is a series of slats nailed on two cross pieces so that the spaces between will form the sizes. The fruit is sized by finding the space it most nearly fits. The edges of the slat must be rounded, so as not to injure the fruit, and even a light padding is advisable. A third form is a series of circles cut in a large board, each circle being a size. The fruit is sized by finding the circle through which the butt end will just pass.

Sizing is also done by weight. This system is probably due to the fact that some canning factories buy by weight. It is figured that a crate holds about 72 pounds and the scale was based on that amount. Because of the very great irregularity in the development of the crown this method is very faulty for pines to be packed for shipment and is not used to any considerable extent.

Whichever system is used it is best to use the larger limit of diameter required to make that sized pack. Make your brand stand for " extra " in every way.

These are the chief methods of sizing, but they have many modifications. They are all faulty in that they measure only the greatest diameter. They are effective in proportion to the care used in grading and the skill in using the system chosen. Here again is work for the horticultural societies. There should be a general scale of sizes adopted and specifications as to what shall constitute a regulation first grade, second grade, etc. Then expert inspectors should be chosen to see that every box comes up to its grade. By this method the Porto Rican fruit can soon make its own market.

The prevailing sizes for Red Spanish are as follows:

	Diameter in inches.
18's; that is, 18 to the crate	$5\frac{1}{8}$
24's; that is, 24 to the crate	$4\frac{5}{8}$ –$4\frac{3}{4}$
30's; that is, 30 to the crate	$4\frac{3}{8}$ –$4\frac{9}{16}$
36's; that is, 36 to the crate	$3\frac{15}{16}$–$4\frac{1}{8}$
42's; that is, 42 to the crate	$3\frac{3}{4}$ –$3\frac{7}{8}$
48's; that is, 48 to the crate	$3\frac{7}{16}$–$3\frac{1}{2}$

Other sizes, such as 20's, 28's, 32's, etc., are sometimes used, but if the regulation crate is employed these make awkward packs, and as a rule do not bring more than the next smaller pack.

PAPER AND WRAPPING.

There is no prescribed paper or method of wrapping; it is not the method, but how well it is done, that counts. The packer can here

show his individuality and establish his brand, and, if necessary, he can have his trade brand registered. By care and originality in this part of the work one can easily make several cents difference in the selling price of his fruit. Poor paper, an unsightly brand, careless wrapping, one or all, will conceal the real merit of the fruit and depreciate its value markedly. It is true economy to use a tough glazed paper that will not absorb the juices of any decaying fruit and break, thus spreading the trouble. When using colored paper, or a brand printed in colors, see that the colors are fast, otherwise should moisture be encountered the fruit will be stained and the brand smeary. It is well to have at least two sizes of paper, one for the large pines and one for the small, as an excess of paper about a fruit detracts from its appearance. When paper with printed brand is used, have the brand as nearly as possible in the same position on each fruit; also see that the fruit is wrapped smoothly and that no unsightly projections, wrinkles, or tears are visible. Place the fruit on its side diagonally at one of the lower corners of the paper and roll tightly, turning in projecting paper at the bottom and gathering the top with a twist around the crown.

BOXES.

There is a standard Red Spanish box used in the trade which is 12 by 10½ by 36 inches with a partition in the middle. The ends are either solid or paneled five-eighths, 1, or 1⅛ inches thick. Some of the most progressive packers claim the solid head makes a firmer, neater, and all-round better head; others favor the paneled; so that it is largely a matter of expense and taste. There are other sized crates in use, some even using the standard lemon and standard orange boxes. The station has tried a special box for the Cabezona because of its size, but at present the majority of the trade recognizes only one size of crate, and it is best that all come up to that standard. The only exception would be a special standard crate adopted by all the horticultural societies of the island and made for a special fancy pack. Such a crate for our fancy fruit could be made very effective if properly introduced. Whatever crate used, the packer should see that the lumber is bright and clean. Nothing injures the appearance of a pack more than a dirty, mildewed, imperfect box. To keep the boxes clean there should be plenty of clean, dry storage room, so that the supply for the season can be laid in when prices are best. This is usually some months before the packing season really opens. This supply is rendered even more necessary here in Porto Rico, where the shipping season is so long. A large storage room will permit the making up of boxes at odd times when outdoor work is impossible.

PLACING IN BOXES.

In packing there are two ways of placing the fruit in the box. The standard way is for the packer to face the side of the box and place the butts against the side nearest him, the number in each layer being governed by the size being packed. The second layer will have the crowns toward him, the fruit being in the spaces between the crowns of the next lower layer. The layers thus alternate, the last one filling the box a little more than flush. The second system, used because of excessive crown development, is to place the fruit across the wider side. This gives a longer space for the fruit, but may change the number of fruits in each layer. While it is always best to adhere to the recognized standards, if possible, yet there are times when it is best to make new standards, and if condition of crown is of much value, this new system has much merit. Certain it is that to pack much of the Porto Rico fruit by the present standard method means to crush and crumple a very large percentage of the crowns, thus injuring the looks of the fruit very seriously. If a brand is used, the fruit should be so placed that it will make a good display when the box is opened. This means that in first and second layers the brand should face what is to be the top of the box and should appear regularly placed.

NAILING.

Depending upon size of fruit being packed, it will take one nailer for every two to four packers. The ends should be nailed first; some packers leave the centers unnailed. As the fruit usually settles, it is advisable to nail the middle to prevent looseness later. If, however, care is taken to pack tightly and exactly, there is less need to nail the middles, and some advantages are to be gained by not doing so. Use a nail with large head, the larger the better, but of small body. The strain is chiefly on the head and a small body is necessary to avoid splitting the slats. Fourpenny wire nails are the ones usually used. These run from 300 to 600 to the pound, depending on size of head and kind.

MARKING, ETC.

Many find it advantageous to mark the boxes, all but the size, before they are packed. A complete stencil will contain brand of shipper, name of fruit, size, grade, consignee, and any necessary shipping directions. To place these in the same relationship toward each other and to place on head of all boxes is not an easy matter, yet if not so placed the effect is bad. A carelessly stenciled head indicates a careless packer and so detracts from the value of the fruit. If solid heads are used, it is advisable to have all the directions made

into one stencil the same size as the head. In this way all the heads will be uniform in appearance. The return for neatness will much more than repay cost of plate. If the paneled head is used, the stencil containing all but size can be made to fit the panel. The marking of the size should be regular and uniform as to position, or it will also mar the effect. Every precaution should be taken to make the head and the whole exterior of the pack as attractive as possible, for it is the part first seen, and uniformity and neatness will do much to bring the best class of buyers and the best prices.

As a final inspection the box should be examined for defects, such as projecting or badly nailed slats, loose packing, and any other points that denote carelessness or slovenliness.

MARKETING ASSOCIATIONS.

If there are any organized, by all means join a marketing association. If there are none, then do all you can to organize one, as no one thing can help more to make the industry a success and thus help each individual grower.

Some of the chief advantages of marketing associations are as follows:

(1) Supplies can be obtained at better rates.

(2) Standards can be established and better maintained, because the manager will have large amounts of fruit to place on the market.

(3) The fruit can be better distributed and loss saved by not glutting one market while others are short.

(4) The whole grade of the fruit and the industry itself will be improved by reason of the knowledge of what the markets desire. This collection of helpful data is alone worth the membership cost.

(5) Better terms can be obtained from transportation companies; also more improvements and appliances for handling fruit.

(6) Markets can be extended and new fields opened.

(7) Inspection, storing, repacking, etc., can each and all be done cheaper and better.

Still other reasons can be given, but surely these are enough to convince one of the value of marketing associations. It is on record that associations have been the means of increasing net profits to the growers 20 to 30 per cent in one year.

SHIPPING.

As the local markets in Porto Rico are small, practically all the fruit must be shipped or canned. In the shipping we are at a disadvantage, as we must depend upon ocean vessels that are ill equipped for carrying such fruit, and, worse yet, during a part of the season

carry large cargoes of raw sugar. Until regular fruit vessels are built, we must make the most of the means at hand. To do this all must work in cooperation. It is not a case for individual action, but for associations. By all acting in harmony better terms may be obtained from the steamship companies. Any definite, practical, necessary convenience will be more easily obtained when demanded by the growers as a body than by individuals.

The system of inspection at the dock is already having good effect, but much should still be done. The chief points to be emphasized are ventilation, care in handling, and care in placing in the hold. These are all only indirectly in the hands of the growers and packers, but should receive their careful attention. If derricks are used to load on boat, the platform system should be demanded. Special care should be taken to see that the stevedores do not handle the boxes roughly.

When placed in the hold the boxes should not rest directly upon one another nor close together, but slats one-half to 1 inch thick should be tacked across the ends. Air spaces should be left between the tiers, thus preventing the crushing of the fruit by jamming and permitting the free and thorough circulation of air about each box.

CANNING.

The canning industry is increasing in Porto Rico. For several years a single factory was run a few months each year during the main crop of Cabezonas. Now canning factories are being built wherever many pines are grown. The natural development for the future is for each neighborhood to have a factory, either cooperative or private. Such a factory can utilize the second-grade and blemished fruits, or, what is more important, take care of the fruit when prices are low, or when, because of soil, fertilizer, or climatic conditions, the fruit does not carry well.

Machinery for handling the fruit in a canning factory has been so perfected and simplified that these neighborhood canneries are entirely practicable. Aside from the pineapple the canneries could utilize many of the citrus and other native fruits, thus enlarging the field of operation and benefiting the island by developing more diversified fruit raising. Not only could these neighborhood canneries take up the canning of other fruits, but they could put in, at a small expense, an extractor and make ciders and denatured alcohol from the fruit not fit to can, thus decreasing the waste and increasing the revenues to the growers. Such work is beyond the experimental stage in other countries, and we should not lag behind in a work of such importance.

PINEAPPLE GROWING AS A BUSINESS PROPOSITION.

Over and over again the question is asked, "Does pineapple growing pay?" Many companies have been organized in Porto Rico and prospectuses published giving, in many cases, grossly exaggerated results based upon some exceptional yield. This being the case, it is well to give some data showing what returns the average planter may expect.

By referring to preceding paragraphs and data gathered from a large number of representative growers, one can reach a close approximation of what ordinarily may be expected. Of course, each item will vary much under different conditions, but the chances are that the totals will not vary so much. Then, too, we are only seeking for the returns that may reasonably be expected, not the bumper returns nor the failures.

Good pineapple land well located now costs from $75 to $200 per acre. To plant this land will take an average of 10,000 slips which at the prevailing prices will cost $150. To prepare the land as it should be prepared means three to six plowings and cultivations. The cost of these will vary somewhat, but will average from $15 to $25, depending on the nature of the soil and wages paid in that particular locality. Bedding, preparing the plants, and planting will cost another $15 to $20. Some, in especially favored sections, get this done for $10, but this is exceptional. After planting, the cultivations will cost on an average $3 to $5 each, and the number for the crop should be at least 6, better 10 or 12, making $20 to $60 for all. Picking and packing will cost from $10 to $20, besides boxes. Adding these we get the cost of the first crop to be from $210 to $275 per acre, not counting cost of land. To this should be added $35 to $50 for fertilizer in the poorer and sandy soils. This will make the cost of preparing the ground, planting, and growing the crop from $250 to $300 per acre.

For the credit side of the account there are the fruit and the slips. In a good stand the average percentage of fruit obtained is about 90. This would give 9,000 fruits. Of these at least 85 per cent, or 637 dozen, should bring an average of 50 cents per dozen if sold at the cannery or more if sold at good average market prices. At the cannery they will bring $318.50 plus $25 for the poorer fruit, thus giving an income of $343.50 from fruit. The income from slips and suckers is almost too variable to approximate. The average from reports from a large number of growers shows four slips, two suckers, and one-half rattoon to each plant. The slips are usually salable at $10 to $15 per thousand, but this is not to be counted upon. It is probable that in a year or two more only first-class slips can be sold at all and these at only $5 to $8 per thousand, but even at these

prices the income will be a valuable factor, for, counting three slips to the plant, 9,000 plants should give 27,000 slips, which at even $5 per thousand would mean $135. Adding this to our fruit returns we have a very safe estimate of $478.50 as returns the first year, leaving a profit of $175 to $225 per acre. This should be greater the second and third years, for there will be no new slips to buy and no bedding. Cultivation and fertilizers will cost a little more, but the total expense incurred the second and third years should be from one-fourth to one-half less than for the first crop.

As said elsewhere, it is not certain as yet under our conditions how long a pine field may be continued, but it is possible that three to four years will be the limit. Every fourth year the expense of preparation, bedding, and planting will recur, but the chief item, that of slips, should still be eliminated, as, once established, a planting should furnish more than the amount of slips needed to continue it.

In conclusion, then, we are probably justified in saying that under normal conditions a pineapple plantation is not merely a good proposition, but ranks among the very best paying of the agricultural industries of the island. Given the right manager and the proper soil, success can reasonably be expected.

DISEASES AND INSECTS.

With a soil properly drained and with good culture, few plants are as free from pests and diseases as the pineapple. It is almost axiomatic that trouble with pineapples means bad management. The troubles thus far known are chiefly due to one of three things: First, an ant and its associate, a mealy-bug; second, wilt; and third, spike.

The station has published a circular on the ant and mealy-bug, with methods for extermination (Circ. No. 7), which may be had on application, so the subject will not be discussed here. It may be said in passing that if in applying fertilizer it is mixed with one-third to one-fourth of its bulk of tobacco dust, or even if tobacco dust alone is thrown in the crown, it will usually prevent the appearance of these pests and will ofttimes cure incipient attacks. The tobacco dust also acts as a fertilizer and as a stimulant to the plant, making it a valuable help to the pineapple grower. In using the dust its value lies in its freshness and strength. It will keep for long periods where it is dry, but leaches quite readily and ferments if allowed to get wet.

WILT.

The disease known as wilt is quite easily recognized, and if taken in time may be controlled. Apparently it is transmitted from one generation to the next, so slips from infected plants should never be

chosen. According to the best information obtainable, the disease is a fungus one, but it acts in a way not clearly understood, and should be met with extreme measures at its first appearance.

Characteristics.—Usually the first sign of the disease is a loss of color, the leaves changing from green to red, then yellow, and finally brown and withering. The withering begins at the tip as a rule, and as it passes down the leaf loses its stiffness and drops, producing the wilted appearance which gives the disease its name. If the attack is not too severe the plant may produce a fruit, but it is usually of poor quality and ripens prematurely.

On cutting off the plant at the base the roots can be traced as dark brown or black points in the stem tissue. A more careful examination shows the whole root system to be diseased. Under the microscope the root hairs are seen to be abnormally developed, and in the diseased parts the fungus threads can often be found, showing that the disease enters from the soil.

Cause.—It is often impossible to tell just how the trouble starts, as it may break out simultaneously in widely separated places. It can probably exist in the soil under some conditions for long periods, and it may be carried from plant to plant by ants and other insects. Its presence is usually due to faulty soil conditions, though Australian investigators claim that it also occurs where a field is cropped too long, and by adhering to one source for supply of plants, as well as poor cultivation and fertilization. They claim that plants grown under different conditions should replace the old ones every few years. In Porto Rico fields have not been running long enough to test these points under our conditions, and the spread of the disease here is probably due to improper soils or faulty cultural methods.

Remedies.—The first precaution to be taken is one of prevention. Never plant a slip that could possibly be already diseased. Second, if the disease should appear, pull out all plants affected, burn them on the spot, or cover with quicklime; also cover the soil with lime and leave exposed to the sun for a few weeks, stirring it from time to time. After a month or six weeks strong, healthy plants may be reset in the vacant places. Third, keep the plants growing vigorously and the soil in the best possible physical condition.

SPIKE OR LONG LEAF.

Characteristics.—Any tendency to spike is quickly evidenced by the leaves becoming long and slender. As the disease progresses, the plant becomes more and more like a bundle of rod-like leaves. In the final stages the central leaves of the plant do not unfold, and thus in their long spikelike form give the name to the disease. A plant at all badly affected rarely produces any fruit; if any is formed

it is small and practically valueless. Plants that are but slightly affected produce very poor, small-sized fruits.

Cause.—In most cases spike is apparently induced by improper fertilizing. Acid phosphate in the fertilizer is one of the most common causes. Wood ashes and any poorly proportioned mineral fertilizer will cause it.

This disease is apparently readily transmitted, and suckers or slips from diseased parents should never be planted. Experiments have shown that fully 70 to 80 per cent of slips from spiky parent plants failed to produce marketable fruits.

Remedies.—First, never plant a slip that is in the least affected with the disease.

Second, for nitrogen and phosphorus fertilizers use tankage, dried blood, bone meal, or other organic forms. If necessary to use acid phosphate, give a good application of lime, 300 to 500 pounds per acre, shortly afterwards. Thomas or basic slag may serve as a source of phosphate, though results from it thus far are not definite.

Third. Cultivate well and often, keeping the soil in the best possible physical condition and plants growing vigorously.

Aside from the above diseases there are several that appear locally, but thus far they have not proved dangerous. Their exact nature has not been fully determined, but they are being thoroughly investigated by the station pathologist.

LEAF SPOT.

The first of these local diseases of the pineapple, which we may call "leaf spot," has occurred quite frequently in many plantations, but only once has it threatened serious damage. It is a leaf disease characterized in the first stages by small brownish spots usually not more than one-eighth to one-fourth inch in diameter. They are regular in outline, but not of definite form. These spots rapidly increase in size, and as they spread the center loses all color as well as turgidity of the cells and becomes like straw-colored parchment. This colorless part is surrounded by a more or less clearly defined zone of the brownish color, indicating the spread of the disease. In its spread the spots usually enlarge faster along the leaf veins, thus assuming a long oval shape. In many cases the edge of the leaf is affected, but any part may be attacked. In time the leaf succumbs and dies.

Cause.—The disease is not fully worked out, but its spread and development is undoubtedly aided by atmospheric conditions. During rainy periods, especially where drainage conditions are not the best, the development of the disease is quite rapid, but is checked by dry weather and culture.

Remedy.—Culture and fertilizing have been the most efficacious means of checking it. Plants kept growing thriftily do not feel its effects and soon grow out of it.

SUN SCALD.

Sun scald is not strictly a disease, but is common and causes so much loss that it is well to consider it here. It is caused by the bending over of the plant so that one side of the fruit is exposed to the direct sun rays. Through moisture adhering to the fruit the action of the sun's rays produces premature ripening and scalding at this spot. Rot soon develops in this scalded part and the fruit is lost. This can be largely prevented by sending boys through the patch every week to put a small handful of dried grass upon every fruit that has fallen over.

TANGLEROOT.

Tangleroot is characterized by the roots winding round and round the stem instead of passing out into the surrounding ground. (See Pl. VI, fig. 2.)

Cause.—It is caused chiefly, if not entirely, by one of two things: Hard soil, or the slip not having been stripped before planting. In our heavier clay soils the ground will often be allowed to become hard. As the young roots are tender and have not much penetrating power, they will follow the line of least resistance. The earth immediately about the stalk is less likely to be hard than that a little distance away; hence the roots follow around the stalk. Again, if the slip is not stripped before planting and the weather and soil conditions are such that the old leaves do not decay, the young developing roots must find their way out between the leaf and the stem, taking a circular direction, which results in tangleroot.

Remedy.—The cure is simple; keep the ground in good cultivation, and if conditions are not very favorable when planting strip the plants.

BLACKHEART.

The disease called "blackheart" has not yet been reported. It is due, apparently, to poor soil conditions and lack of proper food. It is characterized by the rotting of the heart of the pine before any sign of affection is shown on the outside. Any puncture or injury of the fruit will admit some of the many fungus spores that will produce rot. This will spread to the center, but it must not be confused with blackheart.

Remedy.—The cure, as far as known, is better culture and fertilizers. Phosphates and potash are usually the elements needed, especially the latter. Excess of nitrogen will produce soft fruits that easily succumb to all such troubles.

CONCLUSION.

From all that has been said it will be seen that there is at present no reason why anyone should hesitate to plant pineapples if he is willing to take care of them. But if care is not given them, and if any of the above diseases and pests are allowed to increase, then the plantation becomes a menace to the neighborhood.

Again, if heterogeneous importations are made in the future as they have been in the past, it is almost certain that sooner or later some of the other diseases to which the plant is subject will be introduced and much injury done to the industry. Only absolutely guaranteed healthy plants from clean plantations should be allowed to be brought in. In no other line are the laws of the island so important and at the same time so necessary as in the way of controlling and inspecting the importation of plants. The pineapple growers should see that the inspection laws protect them from careless plant importers.

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